



Manufacturing & Prototyping

Nearly Seamless Vacuum-Insulated Boxes

Elimination of most seams would reduce leakage of heat.

Lyndon B. Johnson Space Center, Houston, Texas

A design concept, and a fabrication process that would implement the design concept, have been proposed for nearly seamless vacuum-insulated boxes that could be the main structural components of a variety of controlled-temperature containers, including common household refrigerators and insulating containers for shipping foods. In a typical case, a vacuum-insulated box would be shaped like a rectangular parallelepiped conventional refrigerator box having five fully closed sides and a hinged door on the sixth side. Although it is possible to construct the five-closed-side portion of the box as an assembly of five unitary vacuum-insulated panels, it is not desirable to do so because the relatively high thermal conductances of the seams between the panels would contribute significant amounts of heat leakage, relative to the leakage through the panels themselves. In contrast, the proposal would make it possible to reduce heat leakage by constructing the five-closed-side portion of the box plus the stationary portion (if any) of the sixth side as a single, seamless unit; the only remaining seam would be the edge seal around the door.

The basic cross-sectional configuration of each side of a vacuum-insulated box according to the proposal would be that of a conventional vacuum-insulated panel: a low-density, porous core mate-

rial filling a partially evacuated space between face sheets. However, neither the face sheets nor the core would be conventional. The face sheets would be opposite sides of a vacuum bag. The core material would be a flexible polymer-modified silica aerogel of the type described in "Silica/Polymer and Silica/Polymer/Fiber Composite Aerogels" (MSC-23736) in this issue of *NASA Tech Briefs*. As noted in that article, the stiffness of this core material against compression is greater than that of prior aerogels. This is an important advantage because it translates to greater retention of thickness and, hence, of insulation performance when pressure is applied across the thickness, in particular, when the space between the face sheets is evacuated, causing the core material to be squeezed between the face sheets by atmospheric pressure.

Fabrication of a typical vacuum-insulated box according to the proposal would begin with fabrication of a cross-shaped polymer-modified aerogel blanket. The dimensions of the cross would be chosen so that (1) the central rectangular portion of the cross would form the core for the back of the box and (2) the arms of the cross could be folded 90° from the back plane to form the cores of the adjacent four sides of the box. Optionally, the blanket could include tabs for joining the folded sides of the blan-

ket along mating edges and tabs that could serve as hinges for the door.

Vacuum bags in the form of similar five-sided boxes would be made of a suitable polymeric film, one bag to fit the outer core surface, the other to fit the inner core surface. By use of commercially available film-sealing equipment, these box-shaped bags would be seamed together to form a single vacuum bag encasing the box-shaped core. Also, a one-way valve would be sealed to the bag. Through this valve, the interior of the bag would be evacuated to a pressure between 1 and 10 torr (approximately between 0.13 and 1.3 kPa). The polymer-modified aerogel core material is known to perform well as a thermal insulator in such a partial vacuum.

This work was done by Christopher J. Stepanian, Danny Ou, and Xiangjun Hu of Aspen Aerogels, Inc., for Johnson Space Center. Further information is contained in a TSP (see page 1).

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to MSC-23735-1, volume and number of this NASA Tech Briefs issue, and the page number.

Quick-Change Ceramic Flame Holder for High-Output Torches

In addition to jet engine simulation, this technology can be used in torches for forging and pottery kilns.

Langley Research Center, Hampton, Virginia

Researchers at NASA's Langley Research Center have developed a new ceramic design flame holder with a service temperature of 4,000 °F (2,204 °C). The combination of high strength and high temperature capability, as well as a twist-lock mounting method to the steel burner, sets this flame holder apart from existing technology.

This design features the following:

- Enables about double the torch output without damaging the torch.
- Can operate at a higher temperature [4,000 °F (2,204 °C)] than stainless steel [1,600 °F (870 °C)].
- Allows the torch to be optimized for different applications (e.g., may use a

mixing nozzle or a supersonic nozzle).

- Can be used with either venturi or forced draft burners.
- Is easily replaceable without tools.
- Operates without torch/holder rusting together after use.
- Permits a modified torch to still use a conventional flame holder.

- Uses a twist-lock attachment (an improvement over setscrews).

The high-output flame holder was developed in support of the U.S. Navy's efforts to design a jet engine simulator for infrared plume studies. Previous tests had shown that off-the-shelf components would melt or burn up in a short time. Given these design and performance criteria, NASA developed a ceramic

flame holder that has a much longer life cycle and can be used with a variety of torches or burners. Where the stainless flame holders showed signs of oxidation, flaking after only three hours of testing, NASA's ceramic flame holder has over 150 hours and 200 cycles of use in a casting furnace, and soot marks are the only signs of use; there are no signs of deterioration. NASA expects the new technol-

ogy to help enhance safety through increased reliability and flame control. The total cost of ownership is less due to decreased maintenance and improved efficiency.

This work was done by Henry Haskin of Langley Research Center. For further information, contact the Langley Innovative Partnerships Office at (757) 864-8881. LAR-17502-1

Non-Pyrotechnic Zero-Leak Normally Closed Valve

Goddard Space Flight Center, Greenbelt, Maryland

This valve is designed to create a zero-leak seal in a liquid propulsion system that is a functional replacement for the normally closed pyrovalve. Unlike pyrovalves, Nitinol is actuated by simply heating the material to a certain temperature, called the transition temperature. Like a pyrovalve, before actuation, the upstream and downstream sections are separated from one another and from the external environment by closed welded seals. Also like pyrovalves, after actuation, the propellant or pressurant gas can flow without a significant pressure drop but are still separated from the external environment by a closed welded seal.

During manufacture, a Nitinol bar is compressed to 93 percent of its origi-

nal length and fitted tightly into the valve. During operation, the valve is heated until the Nitinol reaches the transition temperature of 95 °C; the Nitinol "remembers" its previous longer shape with a very large recovery force causing it to expand and break the titanium parent metal seal to allow flow. Once open, the valve forever remains open.

The first prototype valve was designed for high pressure [5,000 psi (≈ 34.5 MPa)] and low flow, typical requirements for pressurant gas valves in liquid propulsion systems. It is possible to modify the dimensions to make low-pressure models or high-flow models, for use downstream of the propellant tanks.

This design is simpler, lower risk, and less expensive than the pyrovalve. Although the valve must be in a thermally controlled state (kept below 80 °C) to prevent premature actuation, the pyrovalves and electrically actuated initiators have far more taxing handling requirements.

This work was done by Rebecca Gillespie of Goddard Space Flight Center. Further information is contained in a TSP (see page 1).

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Goddard Space Flight Center, (301) 286-7351. Refer to GSC-15328-1.

Fast-Response-Time Shape-Memory-Effect Foam Actuators

These actuators have application in variable-area chevrons and nozzles in jet aircraft.

John H. Glenn Research Center, Cleveland, Ohio

Bulk shape memory alloys, such as Nitinol or CuAlZn, display strong recovery forces undergoing a phase transformation after being strained in their martensitic state. These recovery forces are used for actuation. As the phase transformation is thermally driven, the response time of the actuation can be slow, as the heat must be passively inserted or removed from the alloy.

Shape memory alloy TiNi torque tubes have been investigated for at least 20 years and have demonstrated high actuation forces [3,000 in.-lb (≈ 340 N-m) torques] and are very lightweight. However, they are not easy to attach to existing structures. Adhesives will fail in shear at low-torque loads and the TiNi is not weldable, so that mechanical crimp

fits have been generally used. These are not reliable, especially in vibratory environments. The TiNi is also slow to heat up, as it can only be heated indirectly using heater and cooling must be done passively. This has restricted their use to on-off actuators where cycle times of approximately one minute is acceptable.

Self-propagating high-temperature synthesis (SHS) has been used in the past to make porous TiNi metal foams. Shape Change Technologies has been able to train SHS derived TiNi to exhibit the shape memory effect. As it is an open-celled material, fast response times were observed when the material was heated using hot and cold fluids.



Figure: (a) Schematic Representation of the TiNi Torque Tube. The ends are integrated as hexagonal caps as shown in (b) and (c) shows a processed torque tube with a coupling at a representative length scale.